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ABSTRACT

Two passages were written, one on the topic of graphs and one on the topic of sonnets. Sixteen versions of each passage were constructed. Each version contained identical content but different textual manipulations. One hundred twelve community college students and 48 Cornell students participated in the experiment. Each read a single version of both passages, recorded time to read, wrote free recalls of both versions, and then answered a series of probe questions. The community college subjects recalled less of the passages; recalled only isolated pieces of information; and produced recalls which were greatly affected by the presence or absence of explicitly stated logical and relative relations. The Cornell subjects recalled the passages more completely; tended to recall more whole propositions or inter-propositional units; and produced recalls that were not affected by the textual manipulations. It was concluded that logical and relative relations between propositions are part of memory for text, and that the Cornell subjects reflect a population of truly-fluent readers while the community college subjects reflect a population of non-so-fluent readers. (Author)

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The Semantic Structure of Memory for Text

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paper presented at AERA, 4/22/76

This research was designed to probe the structure of memory for text. Specifically, it was designed to answer the following questions: 1) What information in the text consistently becomes part of the readers' memorial representations of the text? 2) How does the content and the structure of memory differ from that of the text? 3) What are the units of meaning used during the process of comprehension? 4) When do the differences between text and recall occur? 5) Is there a specific way to encode information in text so as to produce optimal recall?

In order to answer these questions, one must be able to probe the changes in subjects' memories. Since the structure of memory cannot be measured directly, however, the underlying semantic structure of the text was compared to that of the subjects' recalls. It is assumed, in doing this, that the text is the overt expression of part of the writer's memory and that the recalls are the overt expression of part of the readers' memories. It is also assumed that the structures of the readers' memorial representations are related directly to the structure of the text. Thus changes in the structure of the text should produce predictable differences in recalls.

Much of the research into memory for text has been based, at least implicitly, on these two assumptions. Kintsch and

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his collegues (Kintsch and Monk, 1972, Kintsch and Keenan, 1973, and Kintsch, Kozminsky, Sterky, McKoon, and Keenan, 1975), for instance, have concluded that propositional structure exists in memory which is comparable to the case-based propositional structure which underlies text. Frederikesn (1972, 1975a, 1975b) also conceives of memory as propositionally based. He reached this conclusion by having subjects read or listen to text and then recall it. He found that the linguistic structures of the text were recalled with remarkable accuracy. Thus he concluded that propositions are one aspect of memory structure. Corothers (1972), Meyer (1974), and Clements (1976) all conceive of memory as hierarchically ordered in ways comparable to the ordering of clauses in the text. Thus much of the previous research affirms the relationship between the structure of memory and that of text.

Since it is assumed that differences in text will produce differences in recalls, it was decided to write several versions of a paragraph. Each version was to contain the same content and a different set of structural variables. These variables were

1. Whether or not the logical and causal relations are made explicit in the text (±L). This manipulation appears in two different ways in the text.

+L-- "If a single distribution is represented, bargraphs are best."

-L-- "Suppose a single distribution is represented. Bargraphs

are best."

2. Whether or not the relative relations are made explicit in the text ($\pm$R). This manipulation appears in the text as the presence or absence of camparatives and superlatives.

+R-- "Bargraphs are best." This is +R because the use of the superlative implies that other types of graph are also good and that bargraphs have more goodness than the others.

-R-- "Bargraphs are good." This is -R because no other graph types are implies.

3. Whether the main idea appears at the beginning (MIB) or the end (MIE) of the paragraph. The only difference between these two conditions in expressed in the text as a difference in tense.

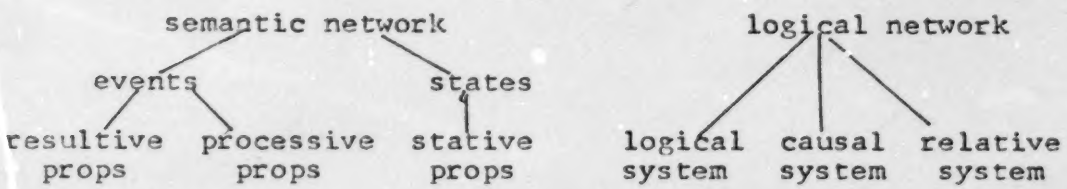
4. Whether a series of clauses from the middle of the paragraph is ordered so that the logical relation considered by the experimenter to be the most important to the understanding of the passage is expressed (MRE) or not (MRN) in the text. This manipulation is expressed in the text as a simple change in order of the clauses.

MRE-- "If two or more distributions are compared, the line graph is better since the superimposing of bargraphs can result in their lines coniciding causing the picture to be confusing."

MRN-- "If two or more distributions are compared, the superimposing of bargraphs can result in their lines coniciding causing the picture to be confusing; thus line graphs are better."

The first two manipulated variables represent the connectedness between propositions and were isolated by employing a system of textual analysis developed by Frederiksen (1975c). In this system, propositional structure (content) is separated from inter-propositional structure (connectedness) as is shown in Figure 1.

Figure 1
Semantic Structure of Text



The last two variables represent a linguistic phenomenon called "staging" by Grimes (1976). Staging is the act of ordering linguistic units so that those in focus appear at the beginning of the utterance. Thus in the MIB and MRE versions, the manipulated propositions are in focus while in the MIE and MRN versions they are not.

In order to incorporate all the possible combinations of the four pairs of manipulated variables into a single experiment, a sixteen-celled design was developed. (See Table 1.) Sixteen versions of the text were written, each version corresponding to a cell in the design. Each version was identified by a letter (A-P) which corresponds to the letters in the design. Thus the textual manipulations for each version can be identified in Table 1.

Table 1
Experimental Design

staging		connectedness			
		-L		+L	
		-R	+R	-R	+R
MRE	MIB	A	B	C	D
	MIE	E	F	G	H
MRN	MIB	I	J	K	L
	MIE	M	N	O	P

METHOD

Subjects

One hundred sixty subjects, ten randomly assigned to each cell of the design, all of whom were enrolled in freshman or sophomore college courses, participated in the experiment. Of these, 112 were enrolled in summer school at Auburn Community College, Auburn, New York, and the remaining 48 were students at Cornell University.

Materials

Two paragraphs of widely different content were manipulated in each of the 16 ways described. One paragraph was about the statistical use of graphs, and the other was about the various types of sonnets. The topics were selected as being appropriate for the target population, students enrolled in community colleges. The two paragraphs were designed to be as similar as possible in structure. Both had the same number of words (115 or 116 depending upon the version), similar logical and relative relations, similar topi-

cal organization, and a similar number of propositions (71 for the paragraph on graphs and 69 for the paragraph on sonnets.) However, the semantic network of each was different because of the difference in content.

Since the manipulated paragraphs were short, each was placed between two paragraphs of related content. Regardless of the version of the manipulated paragraph, the introductory and concluding paragraphs remained unchanged. These paragraphs were controlled for length only. The introductory paragraph for both passages contained 73 words, and the concluding paragraph contained 87 words. The coucluding paragraph was designed to prevent rote recall of the manipulated paragraph.

The materials used were designed for group administration. The first page of the booklet contained the general directions which were read aloud by the experimenter. The secong page contained the passage to be read. The third page contained directions to be read silently and space to write the free recall. The fourth page contained directions for answering the probe questions located on pages five through ten. Thus all the subjects could work on their own regardless of the passage or version read.

It was noted, when scoring the recalls of the 112 community college subjects (hereafter referred to as the ACC subjects), that the recalls for the passage on graphs were superior to those for the passage on sonnets. In order to determine the reason for this, a brief questionaire was de-

veloped. The questions delt with familiarity with the topic and ease of comprehension.

Procedure

Each subject read the same version (A-P) of the passage on graphs and the passage on sonnets. The two passages were presented in random order so as to prevent a practice effect from confounding the results of only one passage.

All the subjects were directed to read the passage in their booklets once in the same way that they normally read material for a course. They were also told to be prepared to be examined on the content of the passage. The type of examination was left ambiguous so as not to provide the subjects with a set before reading. The subjects were also directed to record elapsed time to read on the page following the passage. Time, in five second intervals, was written on the board. As soon as a subject finished reading the passage, he turned the page and wrote down the number currently on the board.

The subjects were allowed 35 minutes to read, write the free recall, and answer the probe questions for each of the two passages. Most subjects finished each passage in from 15 to 20 minutes. One subject needed more than the time allotted. He was permitted to work at his own speed.

After reading and recalling both passages, the 48 Cornell subjects answered the questionaire. The ACC subjects sis not receive the questionaire because it had not yet been developed.

Scoring Procedure

The free and probed recalls for both passages were analyzed using Frederiksen's system. To do this, every item in the recalls was compared to every item in the structure of the text. There were 435 such items in the passage on graphs and 487 in the passage on sonnets. This process yielded a series of 0's (recall different from the text) and 1's (recall equivalent to the text). These numbers were totaled to yeild scores for each of the dependent variables: time to read (Time), recall of the semantic network (SN), recall of the Logical System (Log), recall of the relative system (Rel), recall of the main idea (MI), recall of the major relation in the MRE/MRN manipulation (Maj), and recall of the minor relation in the same manipulation (min).

The recalls were scored by two independent scorers. In every case, one scorer scored the passage on graphs and the other the passage on sonnets. They then switched passages and checked the scoring of the other. Interscorer reliability was .89 when initial scoring was compared and .99 when errors were eliminated from the data.

RESULTS

The recalls of the subjects were analyzed for significant differences using a factorial analysis of variance procedure. Before this was done, however, a t-test of the difference between the two groups of subjects was performed. This showed that the recalls of the Cornell subjects were consistently

more complete than those of the ACC subjects ($p<.001$). These results are reported in Table 2.

Table 2
Population Differences

dependent variables	means ACC subjects	Cornell subjects	t
Time	112.57	117.35	-.85
SN	46.16	95.25	-12.05*
Log	3.36	10.25	-11.46*
Rel	6.73	15.39	-8.79*
MI	29.06	39.82	-4.66*
Maj	.62	1.15	-5.53*
Min	.46	1.31	-7.80*

*$p<.001$

Because the Cornell subjects' recalls were always more complete, it was decided to treat the subjects as representing two different populations. Thus all the subsequent analyses were preformed twice, once for each population.

The primary result of the analysis of variance procedure was a further difference in recall patterns for the two groups of subjects. Not only did the Cornell subjects recall more of the passage, they also produced recalls which were unaffected by the textual manipulations. The ACC subjects, on the other hand, wrote briefer recalls which were significantly more complete when the logical and relative relations were explicitly stated in the text. The staging manipulations did not affect their recalls, however. These results are summarized in Table 3.

This table shows the effect of the textual manipulations upon recall for the semantic network (which was the same in

Table 3
Recall of the Semantic Network

ACC subjects			
textual manipulations	means Level 1	Level 2*	F
±L	40.79	51.56	7.13***
±R	41.83	50.43	4.67**
MIB/MIE	44.48	47.84	.70
MRE/MRN	47.98	44.34	.82
Cornell subjects			
textual manipulations	means Levle 1	Level 2	F
±L	94.24	96.26	.07
±R	96.65	93.85	.15
MIB/MIE	95.86	94.64	.03
MRE/MRN	89.96	100.54	2.09

**p<.1
***p<.02
* In every case, "Level 1" refers to the first in the pair of textual manipulations (+L, +R, MIB, MRE) and "level 2" to the second (-L, -R, MIE, MRN).

all versions). Thus the community college subjects recalled less of the content when the logical and relative relations were not explicitly stated in the text. This effect was stronger for the ±L manipulation than for the ±R. On the other hand, these manipulations made no difference to the Cornell subjects. Their recall for the content remained the same regardless of the structural differences.

Other results were also produced by the analysis of variance procedure. For both groups of subjects, recall for the passage on graphs was superior to recall for the passage on sonnets. (See Table 4.) It was assumed that this difference was the result of the subjects' greater familiarity with the topic of graphs. Thirty-six of the 48 Cornell subjects indicated more experience with the topic of graphs

prior to reading the passages. Only seven indicated more experience with sonnets. No other question on the questionaire differentiated between the two passages to this extent.

Table 4
Differences in Passages

subjects	total recall score graphs	sonnets	F
ACC	58.85	43.56	34.30*
Cornell	144.24	97.44	22.27*

*p<.001

For both groups of subjects, probed recalls were more complete than free recalls. (See Table 5.) This is not sur-

Table 5
Differences in Recalls

subjects	total recall score graphs	sonnets	F
ACC	32.41	80.08	72.33*
Cornell	76.79	164.99	149.19*

*p<.001

prising since the probe questions were designed to access parts of memory not accussed during free recall. Further, when the questions themselves were used as part of a correct answer, the questions were scored as part of the recall structure. Thus parts of the total recall were given to the subjects in the probed recall condition.

As noted in Table 3, the staging manipulations (MIB/MIE and MRE/MRN) tended not to produce significant differences in the recalls of either group of subjects. This result is easily explained for the MIB/MIE manipulation. Re-

gardless of surface order, the main idea occupied the same place in the underlying hierarchy. Thus this was not actually a staging manipulation since staging involves a difference in underlying hierarchical structure as well as surface order. The MRE/MRN manipulation did produce a difference in staging, yet it still made little difference to the recalls. Since it only affected recall for one sentence, this is not surprising.

After the analysis of variance was completed, a frequency count for each item was performed. From this, information about the relative frequency of recall for various pieces of information was indicated. Again, the primary finding indicated further differences between the two groups of subjects. The ACC subjects tended to recall isolated concepts or triples rather than higher-order units such as propositions or inter-propositional units. The Cornell subjects tended to recall whole propositions and inter-propositional units rather than isolated concepts or triples. These results are summarized in Tables 8 and 9.

Table 8
Number and Percent
of Propositions Recalled as Entities

recall type	ACC subjects		Cornell subjects	
	no.	%	no.	%
graphs, free	10	14.08	43	60.56
graphs, probed	9	12.68	29	40.85
sonnets, free	16	23.19	33	47.83
sonnets, probed	13	18.84	18	26.09

Table 9
Number and Percent
of Isolated Concepts Recalled with Greater Frequency

recall type	ACC subjects		Cornell subjects	
	no.	%	no.	%
graphs, free	21	95.45	7	31.82
graphs, probed	8	36.36	4	18.18
sonnets, free	18	56.25	13	40.63
sonnets, probed	23	71.38	6	18.75

As Table 8 shows, the Cornell subjects consistently recalled more complete propositions than did the ACC subjects regardless of the passage or recall type. Table 9 shows that the ACC subjects consistently recalled more isolated concepts than the Cornell subjects regardless of passage or recall type.

Other results of the frequency count indicated that: 1) The first sentence of the main idea was recalled more frequently than all other parts of the text. 2) The second sentence of the main idea was recalled much less frequently. Further, details which supported this sentence, those that indicated the relative benefits of the various graph and sonnet types, were recalled only occasionally. 3) The position of clauses in the underlying hierarchy is directly related to the frequency of recall for the clauses as long as the propositions underlying the clauses are logically related. 4) Recall for the relative system was minimal. This could easily be due to the fact that only half the subjects received versions in which the relative relations were stated. 5) Recall for attributes, operators on relations, and GOAL propositions,

those whose sole function is to indicate that subsequent propositions are goals rather than actual events or states, was minimal. All of these types of information tend to be ignored when people skim. Therefore, they are not as crucial to an understanding of the passage as are other types of information.

Discussion

Semantic memory is knowledge. It is that aspect of memory which is irrevocably combined with language. Thus the devices used to describe language are equally appropriate for describing semantic memory.

From the results, it was concluded that the logical network as defined by Frederiksen (1975c) is an intregal part of semantic memory. The logical network is comprised of two systems: the logical systen (including causality) and the relative system. Since the recalls of the 112 community college subjects were significantly more complete when these two systems were explicitly stated in the text, and since the manipulation of these two systems caused differences in the recall for content, it seems reasonable to conclude that the logical network has psychological reality and, therefore, is part of the structure of semantic memory.

Evidence for staging as an aspect of semantic memory is open to question. Grimes (1976) makes a persuasive argument for staging as an aspect of the semantic structure of connected discourse. As such, it should also be a part of semantic memory. However, the empirical evidence in incoulcusive.

The two staging manipulations had very little effect on the amount of information recalled. For this reason, it is concluded that, although staging is part of language, it may not be part of the structure of semantic memory. Instead, it whould be considered as an operation which is performed during the process of creating text from memory.

The primary differences noted in the results section is that the patterns of recall differed depending upon the population described. The community college subjects produced recalls which were more likely to be affected by the textual manipulations. For these subjects, when the logical relations were explicitly stated and when the relative relations were implied, recalls for the content were more complete. Recalls, regardless of the manipulations, tended to be brief and to contain isolated concepts rather than propositions or inter-propositional units. The Cornell subjects produced recalls which were unaffected by the textual manipulations and were more likely to contain propositions or inter-propositional units.

Several explanations for the differences in the recall patterns of the two populations exist.

1. The Cornell subjects represent a population of truly-fluent readers. A truly-fluent reader is one who can comprehend even poorly written text because he is capable of inferring the missing structural information. Thus the truly-fluent reader must possess superior knowledge about sentence and discourse structure, at least at an intuitive level, and must be able to tap this at need. The ACC subjects, on the other

hand, represent a population of not-so-fluent readers. A not-so-fluent reader is one who is not as likely to pick up the minimal structural cues in the text and/or is not as likely to infer the missing structural information form these cues. This type of reader may easily have a less complete knowledge of sentence and discourse structure.

2. The Cornell subjects could be capable of detecting structural cues and inferring missing structural information because they have read more than the ACC subjects and thus have had more practice in inferring missing information.

3. The Cornell subjects are more capable of inferring the missing structural information because of greater language facility. In other words, the Cornell subjects tend to receive higher scores on standardized intelligence tests.

Unfortionately, it is not possible to differentiate between these explanations at this time. Auburn Community College keeps no test records for students attending summer courses. Thus no outside data can confirm the validity of one or all of these explanations.

Research of this type has applications for the measurment of reading. It can lead to advances in both readability formulae and writing items for comprehension. Traditional readability formulae would predict that the -L versions, because they contained shorter sentences, would be easier to read than the +L versions. The results of this experiment indicate that the opposite result occurred. If one believes that readability should reflect comprehensibility, then some

index of the necessary logical relations should be included in the formulae to offset some of the strength of the sentence length criterion.

Bormuth (1970) pointed out several flaws in the construction of traditional test items. He believes that test items are only arrived at by intuition. To solve this, he proposed constructing items by employing transformations of parts of the text. Since people remember semantic rather than syntactic information (Sachs, 1967), questions based upon semantic structure would be more appropriate. The system of textual analysis used in this research (Frederiksen, 1975c) describes the complete semantic structure of a passage. Thus questions based upon it should be able to fulfill all of Bormuth's requirements while being based on meaning.

Research of the type described in this paper is just beginning to produce results. It is the hope of all that continued research in the area will contribute to the developing picture of the processes which occur as people read and remember text. Reading is a highly complex behavior. Any insights into this behavior can only be helpful to those interested in teaching reading. Thus this type of research can make contributions to both basic and applied research. As such, it is highly valuable.

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